A Hot Water Treatment for Control of the Banana Root Borer, *Cosmopolites sordidus* (Germar) (Coleoptera: Curculionidae), in Banana Planting Stock[1]

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ABSTRACT. Banana corms and all life stages of the banana root borer, *Cosmopolites sordidus* (Germar), were immersed in a circulating hot water bath and subjected to a treatment of 43.3°C for 3 hours to determine phytotoxicity and insect mortality. In a field trial, 21 of 24 treated plants survived. All of 18 treated plants survived in a greenhouse trial. An additional group of 18 plants all survived in a greenhouse following a treatment of 43.3°C for 3.5 hours. Control plants for the three groups exhibited reduced survival. All of the 75 eggs and 160 adult weevils tested died. Post-treatment dissections of heavily infested corms yielded larval (n = 725) and pupal (n = 28) mortalities of 99.9% and 96.4%, respectively. Control larvae (n = 939) and pupae (n = 91) exhibited complete survival.

The banana root borer, *Cosmopolites sordidus* (Germar), is regarded as a serious insect pest of banana and plantain. Prior to its discovery in Hawaii (in the Waimanalo area on Oahu) on July 31, 1981, it was established in nearly all of the major banana growing areas of the world (Woodruff 1969). Subsequently it has spread to the islands of Maui, Molokai, and Hawaii. Plant damage is caused by the larvae which tunnel through the corm where roots and conductive tissues are severely damaged, resulting in secondary infections. The corms are used as planting stock and transoceanic shipments of infested corms probably account for the pantropical distribution of *C. sordidus*.

Several methods to disinfest corms have been explored. *Musa* species are considered intolerant of methyl bromide fumigation treatments by some authors (Fisher 1963, Monro 1972, Anon. 1977, Gettman 1984). However, others report tolerance (Richardson and Roth 1954, Latta and Cowgill 1941). Attempts to drown *C. sordidus* larvae by submersing corms in room temperature water for 24-96 hours yielded principally negative results (Murray 1918, Froggart 1923, Gowdey 1924, Walters 1926). Sein (1934) reported *C. sordidus* mortality in plants grown in a chamber "saturated with moisture" at 43°C for eight hours. Also, a two stage hot water

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treatment (43°C for 30 min. followed by 49°C for one hour) is recommended for corms infested with *C. sordidus* and *Castnia* spp. (Lepidoptera: Castniidae) (Anon. 1976).

This study was conducted to assess the effects of hot water immersions on the survival of *C. sordidus* and of banana corms.

MATERIALS AND METHODS

Uninfested banana plants (*Musa* sp., Cavendish group, "Williams" hybrid) for all tests were acquired from an established field near Punaluu, Oahu. For the phytotoxicity trials, plants were trimmed to an average length of 305 mm and a diameter of 114 mm. Following unreplicated trials testing seven temperature/exposure period regimes, six plants in each of seven groups were treated at 43.3°C for three hours in a 114 liter capacity water immersion tank. Three additional groups of six plants each were likewise treated at 43.3°C for 3.5 hours. The bath was heated by two 1,000 watt thermostatically controlled immersion heating elements and water was continually pumped around a mesh basket which held six plants during each trial. The plants each displaced ca. 1.4 liters and the bath volume was ca. 83 liters. During several treatments, temperatures of the bath and of numerous corms (probed centrally) were measured with thermocouple wires and recorded on a strip chart recorder (Linear Instruments model 255/MM). Following the three hour treatments, 24 plants were transplanted in four replicates in a randomized complete block design in the field. Eighteen plants were transplanted in pots in a greenhouse. The 18 plants treated at 43.3°C for 3.5 hours were also potted and grown in a greenhouse. For each trial, an equal number of control plants was trimmed and planted.

Field-collected adult weevils were maintained as colony stock in aquaria on pieces of fresh banana corms. Susceptibility to the three hour treatment was determined by several methods, depending on the stage. All stages were subjected to the three hour treatment only. Eggs on corm slices were sealed in 7 dram vials. Three vials, each containing 25 eggs, were treated during one phytotoxicity trial. Three control vials were handled identically, excepting the treatment. Following the treatment, eggs were transferred to moist filter paper and observed for eclosion.

Adult weevils, randomly selected from the laboratory colony, were sealed in corm centers for treatment. In each replication ten adults were sealed along with corm pieces in each of four vials. Each vial was centered in a 2 cm diameter hole bored through a corm. The remaining bore was sealed with corm plugs. The trial was replicated four times. Thus, 60 adults were tested. An equal number of control weevils was handled identically, excepting the treatment. Following the treatment, adults were transferred to petri dishes, provided with corm pieces for food, and mortality was recorded over a five day period.

Larval and pupal mortalities were determined by dissecting infested plants 72 hours after treatment. Because field-collected plants were not

infested, the following infestation procedure was devised. Twenty-four untrimmed corms were planted in a caged box, into which 400 adult weevils were released. From 28-34 days after release, four groups of six corms each were removed for testing every other day. Each group (replicate) was randomly divided into three treatment corms and three control corms. The treatment was conducted with three additional uninfested corms in order to standardize the heating dynamics with all other trials.

RESULTS AND DISCUSSION

Figure 1 displays the temperature dynamics of two treatments (43.3°C for 3 hours and 43.3°C for 3.5 hours). Each curve is a plot of average temperature values registered by thermocouple wires probed into the center of three 114 mm diameter corms. The three hour treatment yielded an average maximum temperature of 41.7°C and corm centers returned to

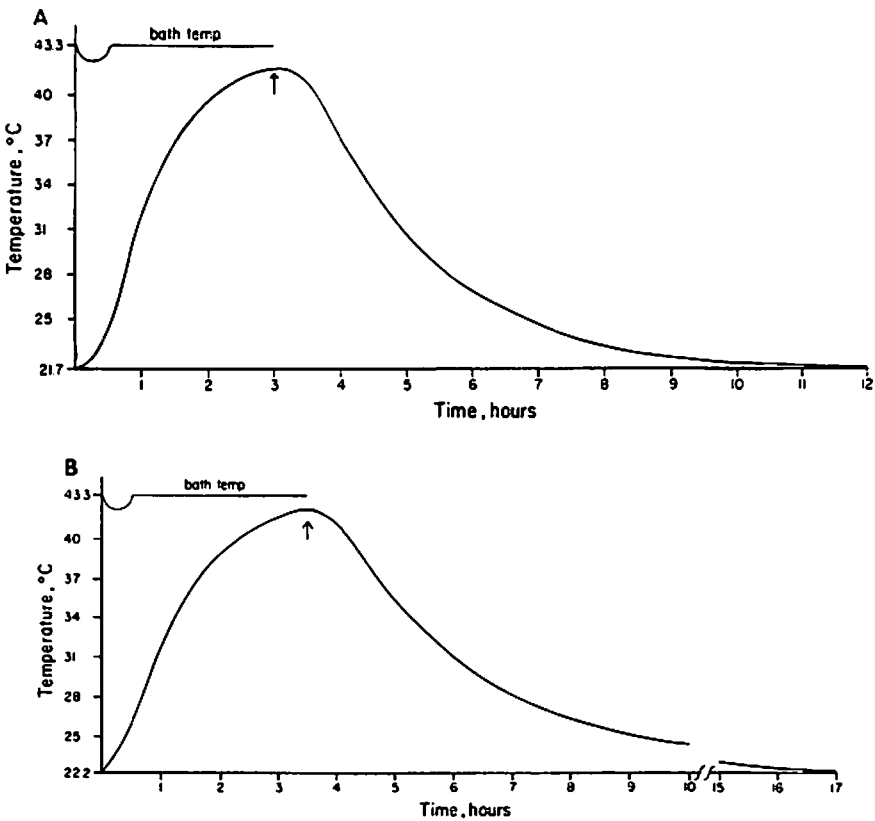

FIGURE 1. Temperature dynamics recorded at banana corm centers during and following hot water treatments of (A) 43.3°C for 3 hours and (B) 43.3°C for 3.5 hours. Arrow indicates time at which corms were removed from the treatment bath.

room temperature by 12 hours. The 3.5 hour treatment yielded an average maximum temperature of 42.4°C and corms required nearly 17 hours to return to room temperature. The brief drop in the bath temperature documents the effect of loading six corms (at room temperature) into the previously stabilized bath. The two thermostatically controlled heating elements restabilized the bath in ca. 20 minutes.

Phytotoxicity trials yielded encouraging results. Among four replicates of treated (43.3°C for 3 hours), field-planted corms, 21 of 24 (87.5%) survived. Among the control group, only 13 of 24 (54.2%) plants survived. The same treatment yielded similar results following greenhouse trials. All of the 18 treated plants survived and 15 of 18 (83.3%) control plants survived. Finally, all of the 18 plants treated at 43.3°C for 3.5 hours survived in the greenhouse and 16 of the 18 (88.9%) control plants for that trial survived. Dissections of the dead control plants from the three trials yielded few *C. sordidus* immatures. The reason for reduced survival among control plants remains unknown.

TABLE 1. Percent mortalities of *Cosmopolites sordidus* (Germar) subjected to a hot water treatment of 43.3°C for 3 hours.

Stage	# Tested	# Died	% Mortality
Eggs			
Treated	75	75	100.00
Control	75	30	40.00*
Larvae			
Treated	725	723	99.99
Control	939	0	0.00*
Pupae			
Treated	28	27	96.43
Control	91	0	0.00*
Adults			
Treated	160	160	100.00
Control	160	0	0.00*

* = Differences between treated and controls were highly significant when tested by chi-square analysis. ($P = 0.001$)

Table 1 lists the results of the treatment's effect on the four stages of *C. sordidus*. All stages exhibited complete or nearly complete mortality due to the treatment. A poor eclosion rate among egg controls may be attributable to damage sustained during egg extraction from corm material prior to treatment. Larval counts represent total numbers of all instars retrieved. An attempt to group larvae by instar was made but head capsule width measurements could not be discretely categorized. The two larvae which survived the treatment were late instars and were retrieved from the center of a particularly large corm (152 mm in diameter). The remaining 169 larvae in the same corm were killed. (Corms were not trimmed to standard

dimensions for this trial to prevent destruction of immatures near the surface.) The one pupa which survived treatment was dissected from near the surface of another large (152 mm diameter) corm. Because exposure to the heat treatment is maximized near the surface, it is speculated that this individual survived as a fourth instar larva which was located deeper in the corm at the time of treatment. It may have subsequently migrated and pupated near the surface during the 72 hour period following treatment and prior to dissection.

In summary, a treatment of 43.3°C for 3 hours does not injure "Williams" hybrid banana corms trimmed to 114 mm in diameter. Extending the treatment to 3.5 hours apparently does not induce phytotoxicity. Unfortunately, longer exposure period trials were not conducted in a replicated manner. Thus, the limit of tolerance to hot water treatments remains unknown. Determining this limit is suggested as a first step in developing a treatment for commercial applications or for quarantine purposes. The high mortalities of all stages of *C. sordidus* in the three hour treatment are highly encouraging. Extending the exposure period would likely produce higher mortalities.

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